IN THE SPECIFICATION:

Please amend paragraph **[0001]** as follows:

[0001] This application is a divisional of application Serial No. 09/941,853, filed August 29, 2001, now ~~US~~ U.S. Patent ~~7,049,693.~~ 7,049,693, issued May 23, 2006.

Please amend paragraph **[0006]** as follows:

[0006] The conventional BGA package 10 may include a plurality of the conductive balls 41 arranged, for example, in an array or arrays of mutually adjacent rows and columns. Referring to FIG. 1, the conductive balls 41 may be arranged in two arrays 60, 70, each array 60, 70 disposed between an edge of the semiconductor die 20 and a peripheral edge of the substrate 30. Each array 60, 70 comprises three columns 61, 62, 63, 71, 72, 73, respectively, of conductive balls 41. The arrangement of conductive balls 41 is typically referred to as the ~~"pin-out"~~ "pin-out" or the "footprint" of the BGA package 10. Those of ordinary skill in the art will understand that the particular pin-out of the BGA package 10 may vary depending upon the application and that the pin-out may be of any suitable configuration.

Please amend paragraph **[0007]** as follows:

[0007] To attach and electrically connect the conductive balls 41 of the BGA package 10 to a ~~substrate such~~ substrate (such as, for example, an MCM carrier substrate or a burn-in ~~board the~~ board), the substrate is configured with a plurality of contact pads arranged in a number of contact pad arrays. Each contact pad array includes a number of contact pads arranged in a pattern corresponding to the pinout of the BGA package 10. The conductive balls 41 of the BGA package 10 may be formed of solder or a conductive or conductor-filled epoxy. If solder, the conductive balls 41 are reflowed to connect to the contact pads of the contact pad array on the substrate. If epoxy, the conductive balls 41 may be first heated to a tacky "B" stage to adhere to the contact pads, and then further heated to completely cure the epoxy to a "C" stage. A substrate may include a plurality of IC devices mounted thereto, wherein each of the IC devices is permanently attached to a corresponding contact pad array on a surface of the substrate. By way of example, an

MCM may be a memory module comprised of a carrier substrate having opposing surfaces, with one or both of the opposing surfaces of the carrier substrate including multiple contact pad arrays and a plurality of IC devices, such as BGA packages, SOJ packages, and/or TSOPs, mounted thereto.

Please amend paragraph **[0008]** as follows:

[0008] During the fabrication of an IC device, the IC device may be subjected to individual component-level testing, such as burn-in and electrical testing. An IC device that exhibits a desired level of performance during component level testing is generally referred to as a "known good device" or "known good die" while an IC device failing to meet minimum performance characteristics may be referred to as a "known bad device." After component-level testing, the IC device may be assembled into higher level packaging, such as an MCM, and again subjected to testing. Testing of higher level packaging such as an ~~MCM referred~~ MCM (referred to herein as module level ~~testing may~~ testing) may include burn-in, electrical characterization and performance evaluation, as well as other desired electrical testing.

Please amend paragraph **[0009]** as follows:

[0009] If an MCM fails to exhibit minimum operating characteristics during module level testing, an IC device causing the ~~failure which~~ failure, which may have previously been identified as a "known good device" during component level ~~testing must~~ testing, must be removed from the MCM and replaced. Also, it may be desirable to introduce a "known bad" IC device into an MCM for module level testing in order to observe the electrical characteristics of the MCM with the "known bad" IC device, or to observe the electrical characteristics of the "known bad" IC device at the module level. After module level testing is complete, the "known bad" IC device must be removed from the MCM and replaced. Thus, although individual IC devices are typically tested at the component level, it is desirable to subject IC devices to further testing at the module level, as a "known good device" may fail at the module level and, further, because incorporation of a "known bad device" into an MCM may be useful in module level testing.

Please amend paragraph **[0010]** as follows:

[0010] To test IC devices in a higher level environment, module level testing is generally performed after the IC devices are assembled into and permanently attached to, for example, an MCM carrier substrate. Thus, if an IC device must be removed from an MCM after module level testing, the permanent electrical bonds between the electrical leads of the IC ~~device for~~ device, for example, the conductive balls 41 of the conventional BGA package ~~10 and~~ 10, and the contact pads on the MCM carrier substrate must be severed. Severing the permanent electrical ~~bonds which~~ bonds, which typically comprise solder or conductive ~~epoxy may~~ epoxy, may cause both heat-induced and mechanical damage to the MCM carrier substrate and conductors, to the electrical leads and electrical bonds of the IC devices remaining on the MCM, and to other electrical components mounted on the MCM.

Please amend paragraph **[0011]** as follows:

[0011] Also, it may be necessary to remove an IC device from a substrate to achieve an upgrade. For example, as technological advances are made by IC device manufacturers, it is often desirable to replace an IC device mounted to a substrate with a next-generation IC device exhibiting improved performance characteristics. To replace an obsolete IC device mounted to a ~~substrate such~~ substrate, such as the carrier substrate of an MCM comprising part of, for example, a personal ~~computer the~~ computer, the permanent electrical bonds between the electrical leads of the obsolete IC device and a plurality of contact pads on the substrate must be severed, which may cause both ~~heat-induced~~ heat-induced and mechanical damage to the substrate and to other IC devices remaining on the substrate.

Please amend paragraph **[0013]** as follows:

[0013] Use of nonpermanent electrical connections between the electrical leads of an IC device and a contact pad array of a substrate can, however, itself cause problems during

module level testing and/or at final assembly. Non-planarities in the substrate, in the conductors forming a contact pad array, or in the IC device itself, ~~may in~~ may, in the absence of a permanent bonding ~~agent result~~ agent, result in poor electrical contact between an electrical lead of the IC device and a corresponding contact pad on the substrate. For example, nonplanarities in the substrate 30 of the BGA package 10, as well as inconsistency in size of the conductive balls 41, may result in unreliable electrical contact between the conductive balls 41 and the contact pads of a substrate in the absence of a permanent bonding agent. Similarly, for other types of IC devices, such as the SOJ package or the TSOP, deflection of their electrical leads as they come into contact with the contact pads on the substrate ~~may again,~~ may, again in the absence of a permanent bonding agent such as solder or conductive ~~epoxy result~~ epoxy, result in poor electrical contact. Poor electrical contact resulting from nonplanarities and/or lead deflections may produce unreliable test data during module level testing or prohibit the acquisition of any meaningful test data and such poor electrical contact may result in nonfunctional, assembled IC device components.

Please amend paragraph **[0015]** as follows:

[0015] The present invention comprises embodiments of a substrate assembly including a plurality of spring-biased electrical contacts for establishing electrical contact with the lead elements extending from an IC device. The substrate assembly comprises a substrate having an upper surface and an opposing lower surface, and the substrate assembly further comprises a layer of resilient conductive material disposed proximate at least one of the upper and lower surfaces of the substrate. The layer of resilient conductive material comprises any suitable conductive material that also exhibits elastic properties suitable for the formation of the ~~spring-biased~~ spring-biased electrical contacts and, further, the resilient conductive material layer may be formed on the substrate using any suitable deposition process or may be a separately formed laminate bonded to a surface of the substrate.

Please amend paragraph **[0017]** as follows:

[0017] A spring-biased electrical contact includes a surface or surfaces configured to bias against and establish both physical and electrical contact with a lead element of an IC device, and the spring-biased electrical contact may also be configured to align the IC device lead element relative thereto. The spring-biased electrical contact may be configured as, for example, a cantilevered spring, a transversely deflecting hoop-shaped spring, a spiral-shaped spring, or a rosette spring. A via formed in the substrate and opening onto at least one of its surfaces may underlie a spring-biased electrical contact, providing a recess into which the spring-biased electrical contact can deflect upon engagement with an IC device lead element. Also, a ~~spring-biased~~ spring-biased electrical contact may be preformed with a permanent deflection towards or away from the underlying substrate surface, in which case a subjacent via may be eliminated. A spring-biased electrical contact may further include one or more contact elements configured to wipe away or puncture through oxides and other contaminants on the exterior surface of an IC device lead element. Further, the substrate assembly may include a layer of dielectric material overlying the layer of resilient conductive material and having apertures therethrough substantially aligned with the spring-biased electrical contacts. The overlying dielectric layer may be of sufficient thickness so that the apertures therethrough assist with alignment of conductive balls or bumps of an IC device to be mounted to the substrate assembly in a flip chip configuration.

Please amend paragraph **[0048]** as follows:

[0048] Referring to FIGS. 3, 4, and 5, the substrate 120 may include a plurality of spring-biased electrical contacts 160 arranged in a two-dimensional array 161 corresponding to the pin-out of the BGA package 10, the vias 126 extending through the substrate 120 also being arranged in a two-dimensional array corresponding to the pin-out of the BGA package 10. With reference to FIG. 5, a BGA package 10 having a plurality of conductive balls 41 may then be nonpermanently mounted to the substrate assembly 100, the two-dimensional array 161 of spring-biased electrical contacts 160 on substrate 120 establishing nonpermanent electrical connections with the conductive balls 41, respectively, of the BGA package 10. Thus, each

conductive ball 41 of the BGA package 10 is engaged with and in electrical contact with a corresponding spring-biased electrical contact ~~160 such~~ 160, such as a cantilevered spring ~~162 formed~~ 162, formed on the upper surface 122 of the substrate 120.

Please amend paragraph **[0051]** as follows:

[0051] In another alternative embodiment, as shown in FIG. 8, the cantilevered spring 162 is suspended over a via 126 that opens only to the upper surface 122 of the substrate 120. The via 126 extends into the substrate 120 a depth sufficient only to provide a relief into which the cantilevered spring ~~162 or~~ 162, or the spring-biased electrical contact 160 ~~generally can~~ generally, can deflect upon contact with a conductive ball 41 (shown in dashed line in FIG. 8) of the BGA device 10. In a further alternative embodiment, as shown in FIG. 9, the cantilevered spring ~~162 or~~ 162, or the spring-biased electrical contact ~~160 generally~~ 160 generally, is positioned directly over the upper surface 122 of the substrate 120 and no corresponding via is provided subjacent the cantilevered spring 162. In the embodiment of FIG. 9, the cantilevered spring 162 is preformed with a permanent deflection outwardly away from the upper surface 122 of the substrate 120, such that the cantilevered spring 162 can deflect downward upon engagement with a conductive ball 41 (shown in dashed line of FIG. 9) of the BGA package 10.

Please amend paragraph **[0052]** as follows:

[0052] In another embodiment of the present invention, the spring-biased electrical contact 160 includes one or more contact elements configured to wipe away and/or puncture through a layer of oxide and/or other contaminants formed on an exterior surface of a conductive ball 41. For example, referring to FIG. 6, the cantilevered spring 162 includes a plurality of grooves 191 formed into the upper surface 164 thereof and separated by ridges 192. Impingement of the ridges 192 of the cantilevered spring 162 against the outer surface of a conductive ball 41, in conjunction with relative motion therebetween, will cause the ridges to wipe or scrape against the exterior surface of the conductive ball 41 and to remove oxides and

other contaminants therefrom. The grooves 191 and ridges 192 may be formed on a ~~spring-biased~~ spring-biased electrical contact 160 using any suitable cleaving or cutting process, and the grooves 191 and ridges 192 may also be formed using a stamping process.

Please amend paragraph **[0055]** as follows:

[0055] A spring-biased electrical contact 160 may comprise alternative shapes or configurations other than the cantilevered spring 162 shown and described with respect to FIGS. 3 through 9. For example, with reference to FIGS. 10 and 11, a spring-biased electrical contact 160 may comprise a transversely deflecting, hoop-shaped spring 262 formed in the layer of resilient conductive material 130. The hoop-shaped spring 262 comprises two semicircular arms 263a, 263b formed within an aperture 136 in the resilient conductive layer 130 and suspended over a via 126 formed in the substrate 120, the respective ends of the semicircular arms 263a, 263b being separated by a gap 264. The semicircular arms 263a, 263b are ~~configured upon~~ configured, upon engagement with a conductive ball 41 (shown in dashed line in FIGS. 10 and 11) of the BGA package ~~10 to~~ 10, to transversely deflect in the plane of the layer of resilient conductive material 130 (as shown by arrows 265a, 265b). A notch 266 located intermediate of the semicircular arms 263a, 263b may facilitate deflection thereof, respectively. Further, the ~~hoop-shaped~~ hoop-shaped spring 262 may also deflect downwardly into the via 126 in a manner similar to the cantilevered spring 162.

Please amend paragraph **[0056]** as follows:

[0056] Thus, the forces exerted by the semicircular arms 263a, 263b as each deflects transversely outward (in directions 265a, 265b, respectively) upon engagement with a conductive ball ~~41 in~~ 41, in conjunction with, optionally, deflection of the semicircular arms 263a, 263b downwardly into the via ~~126 form~~ 126, form physical and electrical contact between the hoop-shaped spring 262 and the conductive ball 41. In addition, the shape of the hoop-shaped spring 262 itself (i.e., the hollow center portion 268) may facilitate alignment between the

hoop-shaped spring 262 and the conductive ball 41. Further, impingement of the semicircular arms 263a, 263b against the exterior surface of the conductive ball 41 in conjunction with relative motion therebetween may result in the scraping of oxides and other contaminants from the exterior surface of the conductive ball 41. To enhance the removal of oxides and contaminants from the exterior surface of the conductive ball 41, the hoop-shaped spring 262 may include a plurality of grooves 191 and ridges 192 (see FIG. 6), a plurality of barbs or protrusions 193 (see FIG. 8), and/or a roughened surface portion 194 (see FIG. 9) formed on its exterior surface or a portion thereof.

Please amend paragraph **[0058]** as follows:

[0058] In another embodiment of the present invention, a spring-biased electrical contact 160 comprises a spiral-shaped spring 362, as shown in FIGS. 12 and 13. The ~~spiral-shaped~~ spiral-shaped spring 362 is formed in the layer of resilient conductive material 130 within an aperture 136, and the spiral-shaped spring 362 extends from a conductive trace 132 and over a via 126 formed in the substrate 120. The spiral-shaped spring 362 includes an upper surface 364 for making physical and electrical contact with a conductive ball 41 (shown in dashed line in FIGS. 12 and 13) of the BGA package 10. Upon engagement with a conductive ball 41 of the BGA package 10, at least a portion of the spiral-shaped spring 362 will deflect downwardly into the via 126, thereby exerting a biasing force against the conductive ball 41 and establishing physical and electrical contact therewith. Also, as shown in FIG. 13, during engagement with the conductive ball 41 and deflection downwardly into the via 126, the spiral-shaped spring 362 may be configured to form a cup or recess 366 for receiving the conductive ball 41 and aligning the conductive ball 41 relative to the spiral-shaped spring 362.

Please amend paragraph **[0059]** as follows:

[0059] To facilitate the removal of oxides and contaminants from the exterior surface of the conductive ball 41, the spiral-shaped spring 362 may include a plurality of grooves 191 and ridges 192 (see FIG. 6), a plurality of barbs or protrusions 193 (see FIG. 8), and/or a

roughened surface portion 194 (see FIG. 9) formed on its upper surface 364 or a portion thereof. Also, the spiral-shaped spring 362 may be used in conjunction with a via 126 that opens only to the upper surface 122 of the substrate 120 (see FIG. 8). Further, at least a portion of the ~~spiral-shaped~~ spiral-shaped spring 362 may be permanently deflected upwardly to increase the deflection of the spiral-shaped spring 362 upon engagement with a conductive ball 41, thereby increasing the biasing forces exerted against the conductive ball 41 and enhancing electrical contact therewith. For a preformed spiral-shaped spring 362 having a permanent upward deflection, the ~~spiral-shaped~~ spiral-shaped spring 362 may be positioned directly over the upper surface 122 of the substrate 120 with no via subjacent thereto (see FIG. 9).

Please amend paragraph **[0066]** as follows:

[0066] To electrically connect the BGA packages 10a, 10b to the carrier substrate 520 of the MCM 500, each of the conductive balls 41a, 41b on the BGA packages 10a, 10b, respectively, is engaged with a mating spring-biased electrical contact 560a, 560b disposed on the MCM carrier substrate 520. Clamping elements 90a, ~~90b which~~ 90b, which are shown in FIG. 16 as stab-in-place clips 95A, ~~95B secure~~ 95B, secure the BGA packages 10a, 10b, respectively, against the carrier substrate 520 to bias the conductive balls 41a, 41b against their mating spring-biased electrical contact 560a, 560b. The spring-biased electrical contacts 560a, 560b, each of which exhibits a deflection as a result of engagement with a conductive ball 41a, 41b, exert a biasing force against their mating conductive ball 41a, 41b and form physical and electrical contact therewith. To facilitate the removal of oxides and contaminants from the exterior surface of a conductive ball 41a, 41b and to enhance electrical contact therewith, the spring-biased electrical contacts 560a, 560b may each include a plurality of grooves 191 and ridges 192 (see FIG. 6), a plurality of barbs or protrusions 193 (see FIG. 8), and/or a roughened surface portion 194 (see FIG. 9) formed on a surface or a portion of a surface thereof.

Please amend paragraph **[0067]** as follows:

[0067] Although the spring-biased electrical contacts or springs 160, 162, 262, 362, 462, 560a, 560b according to the present invention have been described herein in the context of establishing electrical connections with the conductive balls 41 of a conventional BGA package 10, it should be understood by those of ordinary skill in the art that the present invention is not so limited. The spring-biased electrical contacts or springs 160, 162, 262, 362, 462, 560a, 560b may be used to electrically connect the leads of other types of IC packages to a substrate, such as the substrate 120 of substrate assembly 100 or the carrier substrate 520 of MCM 500. For example, any of the spring-biased electrical contacts or springs 160, 162, 262, 362, 462, 560a, 560b incorporating any of the features described herein may be used to electrically connect the lead elements or lead fingers of an SOJ package or the lead elements or lead fingers of a TSOP to a substrate. Also, those of ordinary skill in the art will appreciate that the various features described~~ herein - i.e.,~~ herein (i.e., preformed deflections, via 126 extending through substrate 120, via 126 opening only to one surface of substrate 120, no subjacent via, and contact elements 191, 192, 193, 194, such as grooves, ridges, barbs, or roughened~~ portions - may~~ portions) may be incorporated in any suitable combination with any of the spring-biased electrical contacts or springs 160, 162, 262, 362, 462, 560a, 560b described herein.

Please amend paragraph **[0068]** as follows:

[0068] The present invention also encompasses methods of manufacturing a substrate assembly 100, or MCM~~ 500 - including~~ 500, including substrates 120, 520 and spring-biased electrical contacts 160, 162, 262, 362, 462, 560a, 560b, as described~~ above - according~~ above, according to the present invention. Referring to the flow chart of FIG. 17, from which the methods of the invention may be better understood, various embodiments of a sequence of acts or steps, generally denoted as 600, comprising various methods according to the present invention are shown. One embodiment of such a method begins with the act 610 of providing a substrate. The substrate may comprise an MCM carrier substrate, a burn-in board, or other test board, and the substrate may comprise any suitable material or combination of materials,

including PCB materials, plastics, resins, composites, glasses, ceramics, and other oxide materials, as noted above. The substrate generally includes a first surface and an opposing, second surface.

Please amend paragraph **[0070]** as follows:

[0070] After the application of a layer of resilient conductive material to one or more of the surfaces of the substrate, the act 630 of forming conductive traces, spring-biased electrical contacts, and apertures in the resilient conductive material layer is performed. An etching process, laser ablation process, or any other suitable material removal process, as noted above, may be used to form the conductive traces, spring-biased electrical contacts, and apertures in the resilient conductive material layer. Also, a stamping process may be used to form the shapes of the spring-biased electrical contacts. The cavities defining the conductive traces, as well as the apertures surrounding the spring-biased electrical contacts, extend at least to the surface of the substrate and, optionally, may extend a depth into the substrate. The spring-biased electrical contacts may be configured in one or more two-dimensional arrays, each two-dimensional array corresponding to the pinout of an IC device to be mounted on the substrate. Also, the~~ spring-biased~~ spring-biased electrical contacts may comprise any of the spring-biased electrical contacts described herein or a combination thereof.

Please amend paragraph **[0075]** as follows:

[0075] In another alternative embodiment of a method of manufacturing a substrate assembly according to the invention, the method proceeds according to either of the embodiments described above; however, the method further includes the act 634 of preforming the spring-biased electrical contacts, or a portion thereof. The spring-biased electrical contacts may be preformed to include a permanent deflection either toward or away from the underlying surface of the substrate, as noted above. Such deflection may be imparted to a spring-biased electrical contact by inserting a tool into the associated via and pulling or pushing on the~~ spring-biased~~ spring-biased electrical contact until the contact exhibits the desired deflection.

Please amend paragraph **[0077]** as follows:

[0077] If optional overlying dielectric layer 121 is employed in the substrate assembly of the present invention, it is desirably formed or applied over the layer of resilient conductive material after the formation of all traces, spring-biased electrical contacts and contact elements as previously described. If applied as a film over the layer of resilient conductive material, the overlying dielectric layer 121 may have preformed apertures 123 therein aligned with the ~~spring-biased~~ spring-biased electrical contacts. If formed over the layer of resilient conductive material, the overlying dielectric material may be applied, for example, as a liquid, gel or paste and patterned and etched as known in the art to form apertures 123. Depending upon the dielectric material and etchant(s) chosen, apertures 123 may be formed either in substantially cylindrical shapes with an ~~aniosotropic~~ anisotropic etch or in frustoconical shapes using a substantially isotropic etch.